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THE IMPERIAL COLLEGE OF TROPICAL AGRICULTURE, TRINIDAD, B.W.I.

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TROPICAL AGRICULTURE is published monthly at the Imperial College of Tropical Agriculture, St. Augustine, Trinidad, West Indies. Advertisement and subscription rates can be obtained at the College from the Editor, or from the Secretary of the College, Broadway Bldgs., Westminster, S.W. 1, England. The Editor will be glad to consider authoritative articles for publication. It is understood that opinions expressed or recommendations made in signed articles or in articles of which the source is named are those of the author and do not necessarily represent the policy or opinion of the College Authorities. Increasing numbers of inquiries are being received from the various parts of the tropics which can be answered only by persons possessed of an intimate knowledge of local conditions. Enquirers should first satisfy themselves that their local Department of Agriculture is not able to supply them with the desired information before communicating with us. Correspondence which will be replied to is invited on all other matters pertaining to tropical agriculture, science and development.

THE COLLEGE AND THE WAR.

ON the outbreak of war, the College, like other educational and research institutions, was faced with a number of problems of policy, some arising from the probability that members of the staff would be required for national service, and some from the possibility of reduced income.

In the inevitably unsettled conditions of the first few days of September, there was only one course open, namely, to be prepared for a reduction of activities to a "care and maintenance" basis as soon as possible, and necessary precautions were taken at once. In view of the distance which they may have to travel and the probability that courses could not be completed, all Diploma students were told not to return. Members of the Staff unanimously offered their services to the national cause, and internal arrangements were made for carrying on the essential work of any who might be called up.

It soon became apparent, however, that immediate reduction of College activities was not regarded by the higher authority as desirable. The Colonial Office decided to send its annual contingent of post-graduate students for the completion of their training as agricultural officers, and when this was known, arrangements were made for the College to carry on its normal functions for at least one academic year, that is until July, 1940.

The position will need to be reviewed, both then and periodically as long as the war lasts. The Secretary of State has indicated his hopes that our work will continue for two years, but we have been asked to anticipate the probability of a reduction to "a care and maintenance" basis at the end of that period. Various reductions in expenditure will have to be effected before the end of the current session, but the cutting down will proceed in a manner likely at first to cause as little interference as possible with our main lines of work. The time may come, of course, when still greater sacrifices will have to be made but even then we hope to preserve the continuity of our research work and to maintain all services which are of vital importance to the development of agriculture in the Colonial Empire. Thus, when war does end, the resumption of our normal activities will rest on much surer foundations than if it had been decided to discontinue all our work immediately. We have good reasons to believe

that our plans will have the general approval of those who have contributed hitherto to our funds and that, consequently, we can be assured of financial support as long as our services are maintained.

As it has been pointed out, measures of reduction are considered necessary in order to release staff, as much as for financial reasons. It may be expected that several members will eventually be taken for national service. Mr. S. H. Crowdy, junior lecturer in mycology, has already gone, and we extend to him our best wishes in his new sphere of activities. Those remaining at their posts have already undertaken to do all in their power to carry on the work of those who are called up, so that the absentees will not cease to be identified with their work.

In spite of its disturbed opening, the 1939-40 session is now getting well under way. The Second and Third Year Diploma students were after all able to arrive in time for a normal beginning. The First Year was delayed, because it was felt to be unfair to admit new students unless the completion of their training could be guaranteed. Subsequently, however, when it was discovered that most of the new students had been rejected for military service on account of their youth and were thus unoccupied, it was felt that it would be far better to let these men come even if their training could not be completed. Steps were taken accordingly to begin the course as soon as possible. The First Year students have been warned, however, that there was little prospect of their completing their studies unless war ended earlier than expected. On the other hand, it is hoped that it will be possible to arrange to continue their training as soon as war is over.

As we go to press there are already thirty-nine students in residence and at least another twenty-two are expected to arrive shortly, making a total of sixty-one in all. Of these, thirty-seven will be taking the Diploma course and the rest advanced courses. Most of the students taking the advanced courses are Colonial Office cadets but there are, in addition, two students from Ceylon and one each from India, Portugal, Peru and Belgium. Thus the number of students attending has been well maintained and compares very favourably with previous years.

The monthly publication of *Tropical Agriculture* is to continue but it has been decided to reduce its size as conditions of printing and distributing the Journal are likely to become increasingly difficult as the war goes on. As hitherto, we shall welcome, for consideration, articles from outside contributors and if they are accepted, endeavour to have them published at the earliest opportunity. Our readers may rest assured that no effort will be spared to maintain as far as possible our present standards. We hope, however, that they will extend the indulgence that is always granted to the victims of *force majeure* in the event of their suffering any delay in receiving the Journal.

COCONUT IMPROVEMENT BY SEED SELECTION AND PLANT BREEDING.*

In this paper the problems of coconut breeding and coconut selection are dealt with at length, with a discussion of the relevant literature.

Current practices of the natives and planters of New Guinea with regard to coconut seed selection are outlined; in general any selection practised is of a crude kind, consisting most often of selection from piles of harvested nuts from unknown mother trees. In view of the high variability of the populations of palms in plantations, the need for a more scientific system of selection is stressed. It is suggested that potential mother trees should be marked and their behaviour observed for a number of years before selections are finally made. Desirable characteristics to look for when selecting and various genetic abnormalities to avoid are detailed. A proper system of mother tree selection should be accompanied by rigid exclusion of weak or otherwise undesirable seedlings from the nursery, and by further selection after the palms have been planted out. Yield increases of the order of 20 per cent. may be looked for when proper selection is practised, and it is pointed out that as the palm is a very long-lived plant, the initial cost of selection will thereby be repaid many times.

The questions of regional strains of coconut palm, and of the desirability of introducing such strains, are discussed. The floral morphology and the methods of natural and artificial pollination of the crop are also dealt with.

With regard to coconut breeding, as distinct from selection, very little is known. Experiments are rendered difficult by the great height of the palms and the consequent difficulty of controlled pollination on a large scale. The long interval between generations is a further major difficulty. The practicability of various suggested methods of coconut breeding in New Guinea is discussed. It is suggested that a system of "close-breeding" would be the most practicable means of improvement.

Seedlings derived from individual mother trees would be planted in compact blocks, so that trees in the centre of each block would almost certainly be pollinated by other trees of the same family. Nuts from the centre of the best plots would be used as seed material for the next generation, and selection along the same lines could be repeated for as many generations as necessary. In the later stages, the plots would be arranged in the form of a yield trial. Such a method of coconut breeding is at present being used on a small scale at the Keravat Demonstration Plantation near Rabaul.

A bibliography of 68 references is appended.—(*Imp. Bur. of Plant Genetics, Plant Breeding Abs.* 629, Vol. IX, No. 2, pp. 178-79, 1939.)

* By R. E. P. Dwyer, *New Guinea Agricultural Gazette*, IV, No. 3.

THE CACAO INDUSTRY OF TRINIDAD.

The Rehabilitation of an Old Field.*

A Progress Report.

By C. Y. Shephard.
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Introduction.

Few people in Trinidad retain any faith in the future of the cacao industry. A third or more of the area under cacao can never earn profits unless the price rises to a record level. The outlook for a large portion of the remainder is by no means hopeless but is rapidly becoming so. Yields have declined in consequence of the neglect of cultivation during the depression, of Witchbroom disease, and of the increasing age of the fields. It is of the utmost importance that planters should realise that yields cannot be restored to their old level by a resumption of the traditional method of cultivation because this method does not ensure the replacement of the increasing number of low yielding trees. The only hope of salvation lies in the ruthless elimination of fields no longer capable of earning profits and the systematic rehabilitation of the more efficient fields by an aggressive policy of replacing unprofitable trees.

It is a tragedy that expenditure on " supplying ", or the replacement of dead or unsatisfactory trees, has been reduced instead of being increased during the depression. Money which ought to have been utilised in raising the efficiency of the better fields has been frittered away on hopelessly unprofitable fields and on ungrateful trees which will never show any reasonable response. Many planters have long ceased to supply their fields because the traditional system of supplying every blank space every year entailed a delay of about 15 years before the surviving supplies attained a profitable yield. The abandonment of supplying is a suicidal policy because a field which is never supplied is a wasting asset. Planters who are confronted with immediate financial difficulties may be excused for their reluctance to look 15 years ahead, but with the method of supplying recommended by the writer a tree planted in good soil on a reasonable site within even the oldest field may be expected to give some yield in its fifth year, to pay for its annual upkeep during its seventh year, and to earn profits at an increasing rate in subsequent years so long as it escapes injury.

Experiment in Rehabilitation.

Evidence is here submitted to show that supplies can be brought into profitable bearing at an early age, that the old method of supplying cannot arrest declines in yield and that a policy of rehabilitation can be pursued without the aid of independent financial resources. The records are derived from a field planted 83 years ago on a good alluvial soil (1). Prior to 1934 the traditional practice had been followed of replacing all dead trees and supplying all unoccupied sites every year, but in other respects the method of cultivation approximated to that recommended for rehabilitation. It was, in fact, the unusual vigour and early bearing of the supplies within this field which encouraged the manager and the writer to conduct their first experiment in rehabilitation.

During the season 1931-32 the yield of each tree within the field was assessed, and it was found that 19 per cent. of the total pickets (2) produced no cacao whatsoever, and 40 per cent. of the pickets were unprofitable (3). The money spent on maintaining a high standard of cultivation was wasted on inferior trees but provided conditions suitable for raising supplies, and in 1934 the manager decided to replace the unsatisfactory trees with selected supplies. The selection of poor trees was based upon their general appearance and resulted in the removal of trees from 7 per cent. of the total pickets. This tentative effort represented a courageous advance on previous practice but a re-examination of the field in 1934-35 (4) showed that many poor bearers had been allowed to remain. The previous records of yields were utilised in 1937 to remove unprofitable trees from an additional 7 per cent. of the total pickets (5).

The real test of rehabilitation will come when the supplies planted in 1934, and more particularly those planted in 1937, pass the age of seven years. In the meantime, however, the yield records of supplies planted in earlier years provide evidence which leaves little doubt that the experiment in rehabilitation will succeed in improving the efficiency of the field. The remainder of this article is therefore concerned

(1) For yield diagrams of this field see Maps Nos. XIII, XIIIA and XIIIB in Series III.

(2) A picket is a tree-site which may or may not be occupied.

(3) For reasons explained in Series III, trees yielding not more than 1 lb. of cacao were then deemed unprofitable.

(4) Funds were unfortunately not available for counting this field during 1932-33 and 1933-34.

(5) In Series IV the writer described a simple method by which a planter can identify worthless trees.

* It is assumed that the reader is familiar with "The Cacao Industry of Trinidad, Some Economic Aspects ", Series III, in which an explanation was given of the causes of the declining trend of yield of cacao fields some 15 to 25 years after planting, and Series IV, which recommended a method of rehabilitation designed to improve the efficiency of cacao estates. This publication can be obtained on application to The Editor, *Tropical Agriculture*, price 4/6.

with the histories of supplies planted on 168 sites, or 22 per cent. of the total of 749 comprising the field, between 1924-5 and 1931-2, that is, before the experiment in rehabilitation.

Histories of Young Supplies.

The young supplies on these 168 sites produced a total of 616 lb. of cacao during the five seasons 1934-35 to 1938-39. These sites or pickets would not have yielded a single pod of cacao if supplying had been abandoned because every supply either replaced a dead tree or filled a blank space. A substantial increase in average yield may be expected from these supplies because the oldest are now only 15 years of age and the youngest 8 years old. These supplies undoubtedly benefited from the special cultivation given to the field during the rehabilitation programme of 1934. The drainage system was carefully overhauled and the beds round-ridged or cambered. The trees were pruned, and, in order to prevent overshading the supplies, especial care was taken to trim the trees surrounding them. Bananas, tannias and cassava were planted around the supply-sites to provide ground shade. The growth of ground shade and neighbouring cacao trees was regulated after the supplies had been planted. The supplies were periodically arrondeered (ring-weeded) to prevent competition with weeds, and the fact that not a single supply was ruined by a cutlass wound is evidence of the care exercised in this operation.

Supplies on Unsuitable Sites.

The field has one feature of unusual interest. It lies in the bend of a river and about two-thirds of the length of the bank is low-lying and subjected to annual flooding and scouring (1). A soil analysis showed that the low-lying area has a high index of fertility but it has never given good yields. The writer recommended that cacao cultivation should be discontinued along this fringe but it was decided to ascertain whether deeper drainage and round-ridging would improve conditions. The performances of the supplies in this area are recorded separately from those in the remainder of the field and they make illuminating reading. They support the claim of the writer that supplying on poor sites degenerates into the supplying of supplies.

Supplies were planted on 55 sites in the low-lying area. Only 19 plants have survived without further replacement and of these only four have borne cacao. Two came into bearing at 9 years of age and the other two at 10 years. These four trees have produced a total of 3 lb. of cacao during the past five years, or an average of less than 0.2 lb. per tree per annum. On 36 sites no less than 52 supplies died. Four sites were supplied three times and eight sites twice. A yield at the rate of less than 4 lb. of cacao per acre per annum is an expensive luxury even when the youth of the supplies is taken into consideration. Rehabilitation should not be attempted on defective sites even on good soil types.

(1) The low-lying area can be distinguished clearly in Map XIIIE. For description of Map *see* page 251.

Supplies on Good Sites.

The performances of the supplies in the remainder of the field merit more detailed examination because of the confidence they stimulate in the future of a large section of the Trinidad cacao industry provided planters do not delay rehabilitation too long. The yields are so encouraging as to require no apology, but it should be remembered that each supply occupies the site of a tree which died. It is the writer's thesis that the majority of the failures among the previous occupants were caused by injury to the trees and not by defects in the sites, and this claim is abundantly borne out by the yields of the young replacements. Nevertheless, in a minority of cases the poor performance of the tree removed was undoubtedly due to a defective site, such as the bottom of a ravine. It cannot be expected, therefore, that every supply will give a high yield.

Casualties.—The numbers of supplies of various ages for each of the seasons from 1934-35 to 1938-39 are shown in Table I. Only 12 supplies, out of a total of 113, died or were removed in this portion of the field between 1924-25 and 1931-32.* Four of these 12 supplies were killed by falling shade trees, four had suffered other injuries and were cut out in 1937, and four died.† Seven of them had borne cacao before they became casualties. Only four of the 101 surviving supplies have failed to produce cacao and of these four, three were only 8 years old and one 9 years old in 1938-39. It is probable that these four trees, with a few others which have given poor yields, will be replaced during the next phase of rehabilitation.

Yields.—These 113 sites have yielded a total of 613 lb. of cacao during the past 5 years which is a rate of production sufficient to provide the owner with a small profit over this period. The average yields of supplies of various ages during each of the 5 years are set forth in Table II. An appreciable but unprofitable yield was derived from trees 5 and 6 years old. Supplies seven years old paid for their annual upkeep and in each succeeding year thereafter they earned profits. The 13 year-old supplies brought in a gross revenue equivalent to twice the average total annual expenditure per picket. The average yield of each group of supplies can be traced diagonally across the table for each of the 5 years. For example, the four-year old supplies gave no yield in 1934-35. In 1935-36 they became 5 years old and produced at an average rate of 0.2 lb. of cacao. In 1936-37, when they were 6 years old, they gave 0.4 lb. of cacao, and so on. The yield of a supply tends to increase with its age, but seasonal factors may obscure this trend. The 1938-39 season, for example, was especially poor

* The casualties can be traced in the table. For example, there were 17 supplies 4 years old in 1934-35 but only 15 five years old in 1935-36, two having died or been removed.

† The twelve casualties have been re-supplied and all except one are now alive.

Table I.

Numbers of Cacao Supplies planted in an old field on Alluvial soil between 1924-25 *and* 1931-32 *surviving during the years* 1934-35 *to* 1938-39.

Year.	Numbers of Trees Aged,												Totals.
	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.	13 yrs.	14 yrs.	15 yrs.	
1934-35	17	20	21	13	21	6	6	9	...	...	...	...	113
1935-36	...	15	18	21	13	21	6	6	9	...	...	...	109
1936-37	...	...	15	16	20	13	20	6	5	8	...	...	103
1937-38	...	...	...	15	15	20	13	20	6	5	8	...	102
1938-39	...	...	...	...	15	15	19	13	20	6	5	8	101

Table II.

Yield Histories of Young Supplies in an old (83 *yrs.*) *Field on good* (*Alluvial*) *soil.*

Season.	Average Yield in pounds of cacao per supply aged,											
	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.	13 yrs.	14 yrs.	15 yrs.
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1934-35	0.0	0.5	0.7	0.8	1.0	1.1	0.8	1.5	...	...	...	...
1935-36	...	0.2	0.6	0.9	1.1	1.0	1.4	1.8	1.2	...	...	...
1936-37	...	...	0.4	1.3	1.4	1.7	1.8	1.9	1.1	2.5	...	...
1937-38	...	...	...	0.9	1.5	1.2	1.5	2.0	2.6	1.7	1.8	...
1938-39	...	...	...	...	0.7	1.3	1.3	1.6	1.5	1.5	0.9	1.4
Average	0.0	0.4	0.6	1.0	1.1	1.1	1.4	1.8	1.6	2.0	1.5	1.4

and most supplies gave a smaller yield than in 1937-38 despite the fact that they were a year older. Injuries and deaths may also disturb the trend of yield.

A few of these supplies have given outstanding yields. One, for example, produced 2.7 lb. of cacao when 5 years old, and another 2.4 lb. An 8 year-old supply gave 4.4 lb., and one 12 years old and another 13 years old each bore 6.1 lb. of cacao. Yields such as these would have been considered very good for trees in a field of their own age, but are remarkable for supplies in a very old field.

Some idea of the extent to which the yield of the field would have suffered had the manager abandoned supplying may be gained from Table III which shows the aggregate yield of each group of supplies during each year from 1934-35 to 1938-39. Between 1934-35 and 1937-38, a period of only 4 years, the total annual yield of these supplies had almost doubled. A set back was experienced during the exceptionally unfavourable season of 1938-39, but these supplies may be expected to make an increasingly important contribution to the yield of the field for many years.

These supplies occupied 15 per cent. of the total sites but produced only 1 per cent. of the total yield in the 1931-32 season (See Table IV). Their share of the total yield had risen to 16 per cent. by 1938-39 despite the fact that casualties had reduced their number to 13 per cent. of the total pickets. They are now yielding at a rate higher than the average for all pickets in the field although handicapped by supplies as young as eight years.

The yields given by these and other supplies within this field are most encouraging, but it is important to recognise that they have failed to counteract the loss in yield caused by casualties among the older trees. During the past 14 years the yield of the field has declined at the rate of 3.8 per cent. per annum. A part, but not the

Table III.

Total Yield contributed by groups of Supplies of Various Ages in an old field on Alluvial soil from 1934-35 to 1938-39.

Season.	Total Yield in Lb. cacao produced by supplies aged,												Total.
	4 yrs.	5 yrs.	6 yrs.	7 yrs.	8 yrs.	9 yrs.	10 yrs.	11 yrs.	12 yrs.	13 yrs.	14 yrs.	15 yrs.	
	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.	lb.
1934-35	0.0	9.8	14.4	10.5	20.6	6.5	4.7	13.5	...	...	...	...	80.0
1935-36	...	3.5	10.7	18.6	14.3	20.1	8.7	11.0	11.2	...	...	...	98.1
1936-37	...	...	5.9	20.2	27.7	21.5	34.7	11.4	5.3	20.1	...	...	146.8
1937-38	...	...	...	13.7	22.4	24.8	18.8	38.9	15.7	8.2	14.4	...	156.9
1938-39	...	...	...	...	10.6	19.7	25.3	20.6	30.1	8.9	4.5	11.2	130.9
												Five Years' Total ...	612.7

Table IV.

Percentages of Total Field Yield contributed and Total Number of Pickets represented by Supplies planted between 1924-25 and 1931-32 in an old field on Alluvial soil.

Percentage of Total.	Year.							
	1931/2	1932/3	1933/4	1934/5	1935/6	1936/7	1937/8	1938/9
Yield ...	1	?	?	7	10	15	14	16
Pickets ...	15	15	15	15	15	14	14	13

whole, of this decline may be attributed in theory to the loss in yield caused by the replacement of poor bearing trees by supplies not yet in bearing. In fact the mature trees have benefited from the special cultivation provided for the supplies. It is clear that a resumption of the old system of supplying, no matter how carefully conducted, cannot prevent yields from falling on fields over 15 to 25 years old. There is reason to believe that the larger number of supplies planted in 1934 and 1937 during the process of rehabilitation will soon convert the yield of the field from a falling to a rising trend.

Cost of Rehabilitation.—Planters may object that rehabilitation would make an interesting hobby for a wealthy man, but that financial difficulties prevent them from adopting this policy. It is therefore of interest to note that the present experiment was carried out as a business proposition during the worst financial depression experienced by the cacao industry within living memory, by a planter who has received no extraneous financial assistance beyond the Government subsidy offered to all planters. The subsidy has enabled this planter to accelerate the programme of rehabilitation previously launched.

The rehabilitation policy adopted by this planter has been carried out at an average annual expenditure of $19.94 per acre. This expenditure is actually 26c. per acre less than the average amount expended by 126 Trinidad estates from 1923-24 to 1929-30 when the traditional policy of cultivation was maintained. The expenditure includes not only the field work but also a proportionate share of all other estate expenditure on management and supervision, reaping, manufacture, buildings, taxes, estate supplies and transport of produce to market. This field has brought in an average revenue of $32.13 per acre during the past seven years when cacao was at the very low average price of a fraction less than 7 cents per pound, Port-of-Spain. There are many cacao fields in Trinidad capable of giving equally good results.

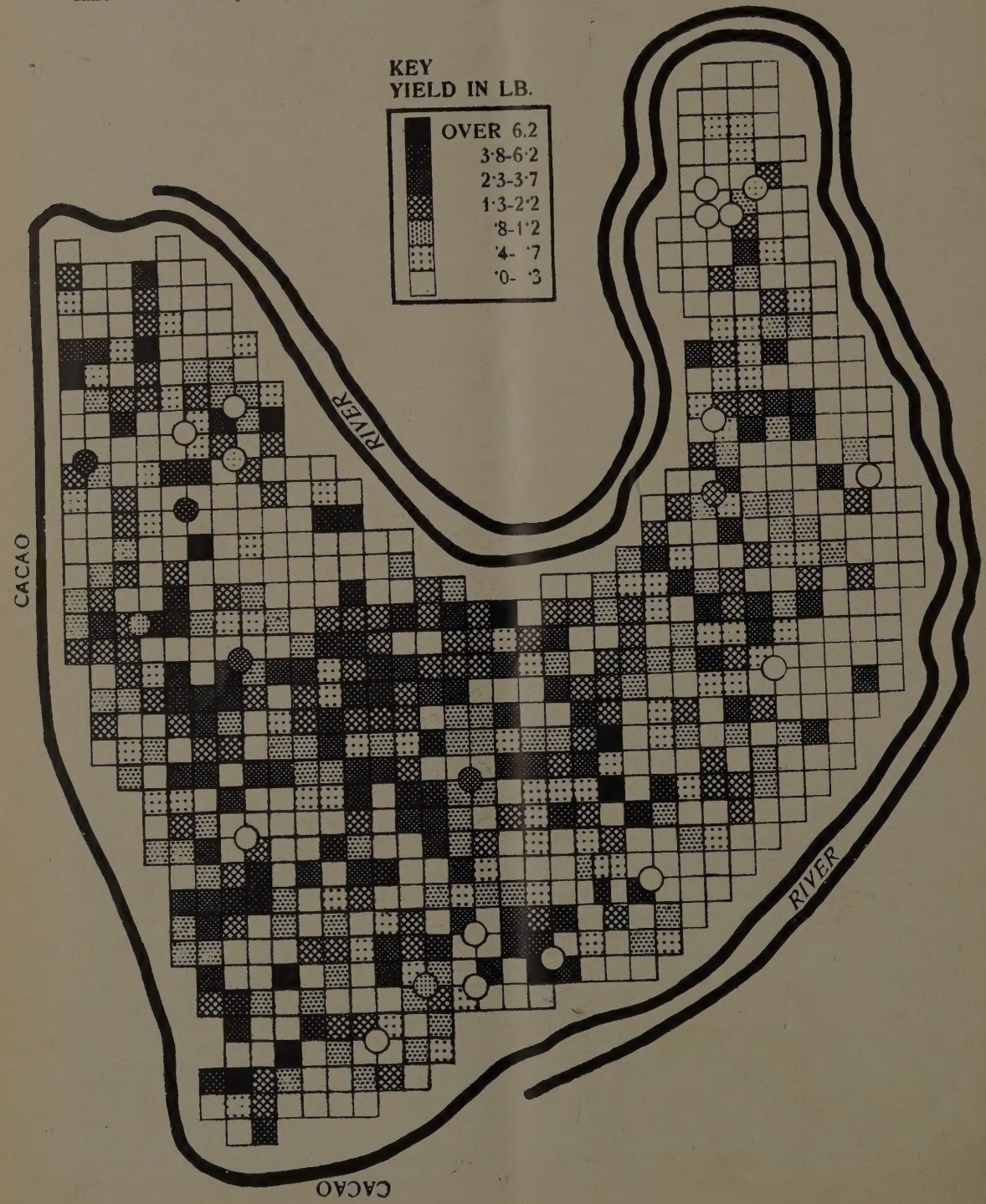
Rehabilitation need not involve additional expenditure and merely requires a change of policy.* Supplies should be concentrated in a few selected fields instead of being scattered throughout the estate. Both drainage and pruning should be attended to in the selected

* See Series IV for a full explantion of rehabilitation.

MAP No. XIIIE.

Yield of Individual Pickets, July 1938 to June 1939, in Field 21A.
Soil : Alluvial. Age of Field : 83 years. Planting distance 12′ × 12′.

Note: Each square represents a picket or tree-site, and each circle an 'extra', 'middle' or 'false' tree. *See* key for yield of each picket.



fields instead of in separate fields. Planters who are willing to abandon hopelessly unprofitable fields can rehabilitate a larger proportion of the area retained than those who insist upon maintaining the cultivation of every field. If planters had devoted the Government subsidy entirely to the rehabilitation of good fields, and had abandoned hopeless ones, the present prospect of the industry would have been much brighter.

Improvements in Rehabilitation.—The knowledge made available by the officers of the Cacao Research Scheme will enable planters to obtain even more spectacular results. More precise tests have been evolved for the selection of planting material, including that for self-compatibility. Vegetatively propagated plants have already proved their merit in a replanted field.* Soil investigations permit a distinction to be drawn between soil types which are suitable, and those which are unsuitable for the process of rehabilitation. Astonishingly large and profitable increases in yield have been obtained from some soils in response to the application of certain artificial fertilisers, while no response, or an unprofitable response, has been derived from the application of artificials to other soils known to be deficient in these elements. The success of rehabilitation is assured in circumstances which can be defined without difficulty.

A bolder policy of rehabilitation can be adopted with confidence now that there is abundant proof that supplies can be brought into bearing in a reasonable time within even the oldest fields. Half the trees in a field on good soil produce only from 10 to 16 per cent. of the total yield. Some of these unproductive pickets are occupied by young but promising supplies and these should be retained, but the majority of the poor bearers consist of mature trees which constitute a drain on the resources of their owner. The replacement of these inferior trees by supplies necessitates the provision of temporary shade such as can be afforded by bananas and ground provisions. Planters therefore have the opportunity not only of securing an improvement in the efficiency of their cacao fields, but also of making a substantial contribution to Government's appeal to grow more food. There is no doubt that at least one quarter of the present acreage under cacao could be made to earn reasonable profits even if the price of cacao remains at a low level, but continued delay in commencing rehabilitation will prejudice the prospects of even the best fields.

* 'Fan cuttings' used to *replant* a portion of a field on Chocolate soil have given heavy yields in their third year. Cuttings have not been tested extensively as *supplies* within established cacao fields. If cuttings are as superior to seedlings when used as supplies as they are in a replanted field, planters would be well advised to replace 50 or even 75 per cent. of the existing trees in their best fields. Trials of cuttings as supplies should be undertaken at the earliest opportunity on the principal soil types uitable for rehabilitation.

Summary.

Selected supplies planted on good soil within old fields may be expected to bear when 5 years old, to pay their way when 7 years old, and to give profits in subsequent years provided they receive special attention.

The traditional policy of supplying every dead tree or blank space throughout the estate every year is expensive, involves a delay of 15 years before supplies give profitable yields, and does not provide a sufficient number of replacements to counter-balance the losses in yield caused by the accumulation of injuries among the surviving trees.

Rehabilitation does not necessitate any addition to the total expenditure of an estate and merely requires a re-distribution of effort. The systematic replacement of low yielding trees by selected supplies will arrest declines in the yields of fields on suitable soils.

The cacao planters of Trinidad must "rehabilitate their cacao fields or perish."

Acknowledgments.

The writer gratefully acknowledges the determined encouragement of Carl and Robert de Verteuil, pioneers in cacao rehabilitation, to whom he owes his continued interest in the industry. From his colleagues of the College and Trinidad Department of Agriculture he has received the most cordial assistance. The investigations, of which this article forms part, could not have been carried out without the financial assistance provided by the Trinidad Government.

Appendix.—Map No. XIIIE.

This map indicates the yield class of each picket. The low yielding area along the low lying bank in the bend of the river is clearly shown. In the higher and better yielding portions of the field there are many scattered individual and small groups of trees which give little or no yield. This is typical of every high yielding field, but there is one important respect in which this field differs from other fields which are equally high yielding but which have not been rehabilitated. In this field every white square and circle represents a tree which is too young to give a high yield. It is probable that every one of these trees except those which occupy unfavourable sites or suffer injuries, will eventually give a high yield. In other fields of similar yield which have not been rehabilitated the white squares and circles represents not only immature trees but also mature trees which for various reasons are incapable of giving high yields. Map XIIIE does not reveal this distinction between this and other fields because only the yields and not the ages of the trees are illustrated.

The season 1938-39 was a very unfavourable one. Maps XIII, XIIIA, and XIIIB in Series IV illustrate the yield of the same field in previous years.

It will be noted that relatively high and low yielding trees in the first year remain relatively high and low yielding in subsequent years except where casualties have occurred or where young trees have risen rapidly in yield.

NOTES ON THE DISEASES AND FRUIT ROTS OF TOMATOES IN THE BRITISH WEST INDIES.

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In the British West Indies tomatoes are grown for export in the Bahamas, Bermuda, Jamaica, Montserrat and sometimes St. Vincent. In other islands such as Trinidad they are grown on a considerable scale for local consumption. Under tropical conditions tomatoes grow readily in the open and produce large crops, especially when grown under irrigation in dry weather. In wet weather tomato culture is far more difficult, and can probably only be carried on satisfactorily in certain specialised localities. Unfortunately pests and diseases are serious and wastage of fruit in transit to North American markets is severe. Tomato diseases in Trinidad have been discussed by Briant (3), and in Bermuda by Russell (9). The low temperature storage and transport of Trinidad fruit have been dealt with by Wardlaw and McGuire (10), and by Wardlaw (11). The object of this article is to discuss certain of the diseases and fruit rots occurring in these islands and to suggests methods for their control.

In 1939 the following organisms were found associated with fruit from Trinidad, St. Vincent and Montserrat. Fruit was picked when full but still green, and was allowed to ripen and rot at a tropical temperature of 75° to 85°F.

It is interesting to compare Table I with Table II which gives the results of Wardlaw and McGuire in 1932 and 1933.

It is evident from these two tables that the important fruit rotting organisms in these islands include the following :—

(i) Soft rots : *Bacillus Aroideae*, *Fusarium* spp., *Phomopsis* spp. and *Botryodiplodia Theobromae*.

(ii) Firmer brown rots : *Fusarium* and *Phomopsis* spp.

(iii) Smaller slow growing dark coloured lesions : *Phoma destructiva*, *Cladosporium fulvum*, and a *Guignardia* sp.

(iv) *Phytophthora infestans* and *Phytophthora parasitica* may cause severe damage during wet weather.

TABLE I.

Causes of Wastage.

Organisms.	Trinidad.			Montserrat.	St. Vincent.
	31.3.39	2.5.39	1.7.39	21.5.39	20.2.39
Acrothecium lunatum	...	...	...	...	1
Alternaria and *Macrosporium* spp. ...	1	...	...	...	2
Aspergillus niger	1	...	...	2	...
Botryodiplodia Theobromae ...	4	...	...	5	27
Cladosporium fulvum	12	6	...	1	1
Colletotrichum falcatum	...	...	...	1	1
Colletotrichum gloeosporioides ...	3	1	1	2	1
Eurotium sp.	...	...	...	...	2
Fusarium spp.	18	...	30	49	12
Guignardia sp.	6	7	6	...	2
Helminthosporium sp.	...	...	...	...	1
Phoma destructiva	6	6	45	2	...
Phomopsis spp.	20	3	13	123	27
Phytophthora infestans	...	...	...	1	...
Phytophthora parasitica	...	...	...	...	...
Pythium sp.	...	...	...	1	...
Rhizopus spp.	2	...	...	...	1
Unidentified fungi	1	...	...	...	1
Bacillus Aroideae	21	...	...	145	1
Other Bacteria	2	...	2	4	4
Bruised, blemished, senescent, &c. ...	1	1	3	209*	17
Bored by *Heliothis obsoleta*... ...	2	...	...	3	...

* This was a large commercial sample of over five hundred fruit which were rejected as they became 'unsaleable'. This figure therefore includes all blemished, bruised, over-ripe and senescent fruit. In the other experiments, consisting usually of one hundred fruit only, such fruit were retained until they were attacked by fungi or became practically 'mummified'. Much of the blemishing was undoubtedly caused by *Phoma destructiva*.

TABLE II.

Causes of Wastage.

	1932.			1933.
	Early Season	Mid Season	Late Season	
Mucor sp.	1	...	...	...
Rhizopus nigricans ...	...	...	1	...
Phoma destructiva ...	...	38	55	205*
Phomopsis sp. ...	33	3	3	6
Botryodiplodia Theobromae ...	...	...	1	2
Colletotrichum phomoides	1	...	...	...
Glomerella cingulata ...	...	1	1	2
Alternaria Solani ...	...	3	9	...
Helminthosporium sp.	2	3	1	2
Fusarium spp. ...	23	5	12	30
Mixed cultures ...	10	8	3	4
Unidentified fungi ...	6	...	...	...
Bacterial infections ...	4	6	9	...
Macrosporium sp. ...	...	...	...	3

From a study of commercial samples it became evident that most of the soft rotting could be attributed to careless handling and to the export of fruit suffering from mechanical damage, growth cracks, blossom-end rot and insect damage. Such fruit are readily attacked by *Bacillus Aroideae, Botryodiplodia Theobromae, Rhizopus* spp., *Fusarium* spp. and *Phomopsis* spp. The two later experiments with Trinidad tomatoes, in which only unblemished sound fruit was taken, showed that by careful selection these rapid-growing soft rots, which do so much damage to commercial shipments, can be largely eliminated. If the soft rots are eliminated, the fungi which finally destroy the fruit will consist of much slower growing organisms, which develop later and do not damage commercial shipments to the same extent.

The primary infection of fruit by many fungi undoubtedly takes place in the field. There is reason to believe that true latent infections of the type described by Baker and Wardlaw (1) are rare. The type referred to, when a sound unripe fruit is infected and the infection remains dormant until the subsequent ripening of the fruit, is commonly produced by *Colletotrichum gloeosporioides* on citrus fruit, mangoes, papaws and other fruit. The evidence indicates that *Phomopsis* spp., *Phoma destructiva, Cladosporium fulvum, Colletotrichum gloeosporioides* and *Guignardia* sp. may occasionally produce infections of this type on tomatoes. But the majority of tomato fruit rotting fungi, including those listed above, usually gain entry through wounds. Under 'wounds' are included cuts, bruises and abrasions, growth cracks, and insect damage. The stem end of a fruit and the blossom end, especially when at all damaged by blossom-end rot, probably constitute other means of entry for fungi. Sucking insects, such as *Phthia picta* Drury, *Leptoglossus balteatus* L.,* and *Nezara viridula* L., are of undoubted importance in this connection. It is well known that sucking insects of this type inject the spores of certain fungi and bacteria into cotton bolls and tomato fruits. Internal boll disease of cotton, transmitted by the cotton-stainers (*Dysdercus* spp.) is the best known disease of this type, and Briant (3) has shown that two of the fungi which cause it, *Spermophthora Gossypii* and *Nematospora Coryli*, and probably *Bacillus Aroideae*, are introduced into tomatoes in a similar fashion causing soft rots of apparently unwounded fruits. Furthermore, tomatoes in the field are probably always heavily dusted with fungus spores which can gain entry into fruit through the wounds made by these bugs. In the experiment listed in Table I, Column 3, the fruit were carefully selected at picking to be as free from wounds as possible. The one hundred fruit so selected were re-examined in the laboratory and the fifty most perfect chosen. Yet, when these fifty fruit were all ripe some fourteen days later, only twenty-nine could be considered perfect, the other twenty-one all having blemishes of some kind which would have detracted from their commercial value. Most of these blemishes were small black spots caused by *Phoma destructiva*, and in the centre of each spot there was a small hole apparently caused by the mouthparts of one of these large bugs. These spots occurred in any position and were invisible when the fruit was green. This type of latent infection is really a wound parasite which has a dormant period between infection and further development. The sequence of the events suggested is as follows. Spores of fungi such as *Phoma destructiva* and *Cladosporium fulvum* are produced on stem and leaf lesions and are carried on to the fruit by wind or rain. The Coreid and Pentatomid bugs already mentioned feed on the green fruit making wounds, which exude a drop of juice in which the spores can germinate. Infection takes place, but the fungi remain dormant until the fruit reaches a stage of maturity at which their further development is permitted. Finally these slowly developing fungi are often outgrown by more rapid organisms such as *Phomopsis* and *Fusarium* spp. which can grow through them, and rapidly complete the destruction of the fruit.

Growth cracks constitute an important source of wounding of tropically grown tomatoes. When the water-supply is irregular and especially when plants receive a heavy rainfall after a period of drought, cracks radiating from the stem end or encircling it and sometimes spreading all over the fruit, develop. Such weather conditions are of course equally conducive to

* This high figure is presumably reached because *Phoma destructiva* will bring about blemishing of fruit which is often afterwards destroyed by other organisms.

* I am indebted to Dr. Callan of this institution for these identifications.

blossom-end rot, and irregularity of water-supply to growing tomatoes must be avoided as far as possible. These cracks often appear to heal, but it is quite likely that infections of certain fungi have meanwhile become established in them.

Wounds of the type of bruises, abrasions, cuts and scratches made during the picking, grading or packing of fruit are especially likely to become infected by fungi. Since such infections are likely to develop in transit they must at all costs be avoided. Fruit is also damaged by being allowed to rub against the stakes to which the plants are tied.

The following suggestions for reducing wastage in shipments of tropically grown tomatoes are made.

Firstly, due care must be given to the cultivation of the crop. It is not proposed in this article to discuss the cultivation of the tomato in the tropics, but it must be realised that even the most up to date packing and shipping organisation cannot do first class work with inferior fruit. In addition to producing good fruit of the correct size, growth cracks and blossom-end rot must be avoided; and if they are at all common, the larger sucking bugs must be controlled. Secondly, fruit must be picked at the correct stage of maturity which will ensure its reaching its market neither too green nor over-ripe. Care must also be taken to avoid damaging it in any way either in picking or at any subsequent stage in the grading and packing. Thirdly, all fruit must be carefully inspected and *all* damaged fruit rejected. However insignificant the wounds may appear at the time, damaged fruit are almost certainly infected by one or more of the fungi discussed in this article. These fruit will rot and will spoil the pack before it can be sold, and it only takes two or three fruit destroyed by *Bacillus Aroideae* to ruin the appearance of a whole box. Notes on some of the fungi and bacteria which cause diseases and fruit rots of West Indian tomatoes are appended. Most of the latter cannot be distinguished by their macroscopic symptoms, and must be isolated into pure culture for identification.

1. Alternaria and Macrosporium spp.

Several species, probably including both *Macrosporium Solani* E. & M. and *Macrosporium tomato* Cke. and other species occur, but are of little or no economic importance on fruit or on foliage.

2. Botryodiplodia Theobromae Pat.

This fungus is very common in Trinidad and was also isolated from Montserrat and St. Vincent tomatoes. It causes a soft rot of a large number of tropical fruits including citrus. While it is very closely allied to *Diplodia natalensis* Evans, the common cause of stem-end rot of citrus fruit elsewhere, it can probably be distinguished by its somewhat larger spores. *Botryodiplodia Theobromae* does not usually attack Trinidad tomatoes to any great extent, but the sample from St. Vincent was severely damaged by it. As this fungus is a wound parasite pure and simple, its control should present few difficulties. The St. Vincent fruit must have become contaminated with spores of the fungus from some outside source, as it is very improbable that *B. Theobromae* can fructify on a living tomato plant.

3. Cladosporium fulvum Cke.

Cladosporium fulvum Cke. is the cause of the common leaf disease known as Leaf Mould. It also occasionally attacks the fruit, but whether it is a wound parasite with a dormant period or a true latent infection is not known. It produces small, dark, olive-green, sunken lesions which spread slowly and only develop in the later storage life of the fruit.

4. Colletotrichum spp.

Colletotrichum phomoides (Sacc.) Ches. was recorded once by Wardlaw from Trinidad fruit, and *Colletotrichum falcatum* Went. occurred twice in Montserrat and St. Vincent fruit during the present investigation. *Colletotrichum gloeosporioides* Penzig. is more common, but still of comparatively little importance. It has been demonstrated that this fungus behaves as a true latent infection of the tomato.

5. Fusarium spp.

Fusarium Lycopersici Sacc., *F. semitectum* Berk. & Rav., *F. arthrosporioides* Sherb., *F. succisae* (Schroet.) Sacc., and other species have been isolated from West Indian tomatoes. They are all wound parasites, and, as stated by Briant (3) their mere presence is an indication that the fruit has been damaged in some way. *Fusarium* spp. constituted an important cause of wastage in fruit from all three sources in 1939, and it is indicated (Table I, Column 2) that their incidence can be considerably reduced by the careful selection of fruit.

6. Internal Boll Disease Fungi.

The occurrence of *Spermophthora Gossypii* Ashby & Nowell and *Nematospora Coryli* Peglion on tomatoes in Trinidad has been fully discussed by Briant. In spite of the presence of bugs of several species on the tomatoes this year, no cases of this disease were seen.

7. Phoma destructiva (Plowr.) Jamieson.

This fungus produces a dark sunken lesion which spreads slowly, and is practically indistinguishable from lesions of *Cladosporium fulvum* and *Guignardia* sp. *Phoma destructiva* is often followed by secondary rots such as *Phomopsis* or *Fusarium* species and itself seldom totally destroys fruit. It is an important cause of 'blemishing' and the small, dark-coloured lesions of this fungus are especially common near the 'button'. It occurs commonly in the field, causing leaf spots and stem lesions, and there can be little doubt that fruit

are infected or contaminated with its spores before they are picked. Furthermore, it is probable that large numbers of infections of this fungus are established in cracks, cuts, abrasions and insect punctures in fruit before it is harvested.

8. Phomopsis spp.

One species, indistinguishable from *Phomopsis Citri* Fawcett has been identified. This species occurs commonly in Trinidad causing fruit rots of citrus, mango, avocado pear, papaw, cacao and other fruits. Several unidentified species, whose symptoms on tomato fruit are indistinguishable from those of *Phomopsis Citri* also occur.

Although wastage due to *Phomopsis* species is of considerable importance on West Indian fruit, it does not appear to have been described from other countries. During the 1932 dry season Briant (3) isolated these fungi from more than 50 per cent. of the diseased fruits from which isolations were made, and Wardlaw regularly obtained *Phomopsis* species from tomatoes in storage. In wet weather, Briant found that their incidence was frequently masked by the occurrence of other diseases. During 1939 *Phomopsis* species were regularly isolated from tomatoes from Montserrat, St. Vincent and Trinidad. A soft watery or a firm brownish rot may be produced, depending on the condition of the fruit attacked. Lesions often develop near the stem end but may appear anywhere on the fruit. They can often be identified by the masses of mycelium which break through the epidermis and later develop the pycnidia of the fungus. The source of infection is not known, but it is probable that latent infections occur, as it cannot be entirely eliminated by careful selection and surface sterilisation of fruit.

9. Phytophthora spp.

Phytophthora infestans (Mont.) de Bary, *P. parasitica* Dastur, and *P. cryptogea* Pethyb. & Lafferty all cause fruit rots of the tomato, but only the first two species are known in the West Indies. *P. infestans* is common and may do considerable damage in Bermuda, Jamaica and Montserrat, but it is not recorded from St. Vincent or Trinidad. *P. parasitica*, a more truly tropical species, is common in Trinidad St. Vincent and Montserrat, and probably, Jamaica. Both species attack fruit at any stage of maturity, but *P. parasitica* is usually limited to the lower trusses, as it is a soil-borne disease. They can be distinguished macroscopically as follows: *P. infestans*, often known as 'Late Blight' produces a soft, brownish, watery rot covered with the aerial mycelium and sporangia of the fungus; *P. parasitica*, on the other hand, which is known as 'Buck-eye Rot', produces a firm, brown concentrically zoned lesion with little or no aerial mycelium.

10. Corticium Solani Bourd. & Galz.

This fungus which is probably better known under the name of its conidial stage, *Rhizoctonia Solani* Kühn, is widely distributed both in the tropics and in temperate regions. In the United States it is described by Ramsey and Link (8) as a serious cause of fruit rotting. In the West Indies it has been recorded on tomatoes by Russell (9) in Bermuda and in Puerto Rico by Matz (5). Briant did not observe it in Trinidad in 1932, nor was it found during the past season although the fungus occurs commonly on other crops. In the United States, according to Ramsey and Link, wet conditions are necessary for the disease and it only attacks fruit which are very near or in contact with the soil. This disease is only ever likely to occur to a serious extent on unstaked tomatoes and should be easily controllable by proper staking.

11. Rhizopus spp.

Fungi of this genus including *Rhizopus nigricans* Ehrenb. commonly cause soft rots of various fruits including tomatoes in the United States and elsewhere. Rots of this type occur occasionally in Trinidad, but are of little importance.

12. Bacillus Aroideae Towns.

This bacillus, which is closely allied to *Bacillus carotovorus* L. R. Jones, is one of the most serious fruit rotting organisms of tomatoes in the West Indies. It is commonly called 'Bubbly Fruit Rot', 'Bacterial Soft Rot' or 'Leak' and attacks fruit both in the field and after it has been harvested. Both green and ripe fruit are attacked and are quickly reduced to an evil-smelling watery mass. This complete dissolution of the fruit is serious as it only takes two or three rotten fruit to spoil the appearance of a crate. The wrapping papers become sodden and the good fruit covered with foul smelling juice.

Bubbly fruit rot is commoner in the wet season than in the dry season, but Table I shows how common it is even in the dry months of March, April and May. This organism is almost certainly a wound parasite and fruit which is attacked after harvesting must have been contaminated in the field. Secondary infection probably occurs to a considerable extent in boxes when sound fruit are contaminated with the juice of those which have rotted. Little is known about the life history and method of entry of the bacillus into tomatoes, and since it is one of the most serious fruit rots of West Indian tomatoes it would probably repay investigation. Infection experiments demonstrating the pathogenicity of the organism and its transference by sucking insects have been carried out by Nowell (7) and Briant, but a full re-investigation of the problem is desirable.

13. Blossom-end Rot.

This non-parasitic disease is well known in the tomato growing countries of both the temperate regions and the tropics, and is common in the

West Indies. The tomato plant requires a carefully controlled water-supply throughout its life—too much water predisposes it to wilt diseases, and a fluctuating water-supply causes blossom-end rot. Where tomatoes are grown in a hot climate in the dry season as they are in Trinidad, and plants have to be irrigated, or watered by hand, this disease is common. When plants are heavily watered after they have partially wilted on a hot day the disease is almost certain to develop. Heavy waterings at long intervals are probably more conducive to the disease than are more frequent lighter applications.

The disease can easily be recognised by the appearance of a grey, brown or blackish, sometimes sunken lesion at the distal or 'blossom-end' of the fruit. The lesion varies in size from a few millimetres in diameter to the size of a penny piece; affected fruit is often attacked by secondary rots, and in all but the mildest cases, is worthless. A plant once affected appears to go on producing diseased fruit for some time, and the water-supply must be carefully controlled not only when the plants are carrying fruit but even before the flowers appear. According to Bewley (2) drought is the commonest cause of the disease. Plants growing rapidly and producing soft, sappy shoots are more susceptible to a check caused by drought and are more prone to the disease. He adds that heavy dressings of stable manure and ammonium compounds favour the progress of the disease, while nitrate of soda and lime appear to check it.

14. Helminthosporium spp.

Unidentified species of this genus occur occasionally, but are of no commercial importance.

15. Guignardia sp.

An unidentified and probably undescribed species of *Guignardia* is a common latent infection of citrus fruit, mangoes, avocado pears and papaws, but has never been observed to cause any rotting of the above fruit. It is of some interest therefore to record that it produces a firm, black, slowly developing rot of tomatoes similar to that produced by *Phoma destructiva* and *Cladosporium fulvum*. Here again, infection undoubtedly occurs in the field, but although this fungus is presumably of common occurrence, its natural habitat whence comes the supply of spores infecting so many different fruits has not yet been found.

16. Wilt Diseases.

Five organisms, *Bacterium Solanacearum* E. F. Smith, *Fusarium Lycopersici* Sacc., *Verticillium Dahliae* Klebh., *Verticillium albo-atrum* Reinke & Berth. and *Sclerotium Rolfsii* Sacc. are known to attack the root-systems of tomatoes causing wilt diseases. Of these, the two *Verticillium* species are not known in the tropics although they are widespread in Europe and North America, and *Verticillium albo-atrum* is also recorded from Australia and New Zealand. *Fusarium Lycopersici* is recorded from Europe, North America, the West Indies and British Guiana, India, Australia, New Zealand and South Africa. *Sclerotium Rolfsii* has a more restricted distribution, being recorded on tomatoes only from Denmark, Canada, the U. S. A., Philippine Islands, Ceylon, Jamaica, Trinidad and Guam. *Bacterium Solanacearum* also is widely distributed, occurring in Europe, North, Central and South America, the West Indies, Australia, Japan, Dutch East Indies, Pacific Islands, Ceylon, and parts of Africa. As noticed by Briant, its range indicates that it is of more account in hot climates than in cool ones.

In the West Indies, it is probable that one or more of these organisms occurs in every island. Briant (3) has given a full description of the three which occur in Trinidad (*Fusarium Lycopersici*, *Sclerotium Rolfsii* and *Bacterium Solanacearum*); Russell (9) has described the occurrence of *Fusarium Lycopersici* from Bermuda; and *Bacterium Solanacearum* and *Fusarium Lycopersici* are known to occur in Jamaica [Hansford (4)] and Puerto Rico [Nolla (6)]. An unidentified wilt is present in St. Vincent.

Under West Indian conditions any one of these organisms can cause serious losses, and soil which has become thoroughly infected is likely to remain so for many years. The spores in addition to being soil-borne, are sometimes seed-borne and seed disinfection has been suggested as a control measure. A better method is an extended crop rotation, in which care must be taken not to grow any other solanaceous or susceptible crops, but this is almost impossible with *Sclerotium Rolfsii* as its host range is so wide. The only direct control measures possible are rogueing and field sanitation. Nevertheless, it is likely that provided tomatoes are not grown too often on the same field, and not in excessively wet weather, and are neither starved, nor over-fertilized with nitrogenous manures, these diseases should not be a serious menace. The raising of out-of-season fruit is a specialised business and will obviously require a special technique. No really satisfactory immune varieties are at present available.

17. Stem and Leaf Diseases.

This group of diseases is important for two reasons. Firstly, it reduces the leaf area and obstructs the vascular tissue of the plant, so interfering with its vital processes. Secondly, since most of these fungi infect the fruit also, leaf lesions form an abundant supply of spores which will later be carried on to the fruit. Four important diseases, all occurring in the West Indies, will be discussed here. For a full description of *Cladosporium fulvum* Cke. (leaf mould), *Septoria Lycopersici* Speg. and *Phoma destructiva* (Plowr.) Jamieson, the reader is referred to Briant's paper on tomato diseases. They occur wherever tomatoes are grown in

temperate and tropical countries and have the following points in common. Their macroscopic symptoms cannot be distinguished with any certainty in the field, and identification of their spores under the microscope is the only satisfactory method. They can almost always be found on the oldest leaves, but provided the weather is not excessively wet, or the plants are unthrifty for any reason, or are becoming senescent, they should not assume serious proportions. They are serious on tomatoes grown in wet weather in the West Indies, but could probably be controlled, at a price, with copper sprays. Both *Cladosporium fulvum* and *Phoma destructiva* attack fruit, and the stem and leaf lesions provide the source of spores which contaminates the fruit.

In addition to the above, a biologic form of the potato-blight fungus, *Phytophthora infestans*, attacks tomatoes grown in the open in many countries. It seldom attacks tomatoes under glass. In the West Indies it is recorded in Bermuda by Russell (9), in Jamaica by Hansford (4) and also occurs in Montserrat. This disease is at its worst in cool humid weather and possibly the reason why it has not been observed in Trinidad is because tomatoes are usually grown in the dry weather. On the other hand the climate may be too hot for it. Attacked leaves first appear water-soaked, then turn brown and finally black, and bear a whitish, downy fungal growth which contains the spores of the fungus. Under favourable conditions the disease spreads with great rapidity and is capable of blackening and destroying the whole crop in a few days. It can be controlled by means of copper sprays, but it must be remembered that such sprays are protective only and must be applied before the outbreak of the disease to be satisfactory. It is likely that this disease is less serious in the tropics because the cool damp conditions required for its development seldom occur.

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A NEW TEAK PLANTING TECHNIQUE.

In the past, teak plantations were formed either by direct sowing of the seeds or by transplanting small seedlings at the beginning of the rains, but with either of these methods, results were frequently irregular, and partial failure of the plantations was a common experience. The rate of growth of the young teak plants raised by these methods was moreover slow and the cost of keeping them from being swamped by the vigorous weed growth experienced in moist west-coast localities was correspondingly high.

More recently, experiments conducted in Madras, by A. L. Griffith (*Indian Forest Records*, Silviculture, 3, No. 2) have proved that far more regular results can be obtained by planting out stumps, prepared by digging up one-year-old nursery seedlings and cutting off the shoot at about one inch above and the root at about 8 or 9 inches below the original ground level and trimming off all side roots. These stumps are much more resistant to adverse weather conditions after planting, give higher survival percentage and grow faster than either direct sowings of seed or planted nursery seedlings.

Carefully planned experiments have shown that the best date for planting was mid-April or early May. The survivals may be as high as 99 per cent. The results were unexpected and surprising. The stumps very often experienced an almost complete drought for anything from ten days to three weeks after planting, while the soil was baked hard and dry. At first it seemed inconceivable that they could survive such early planting and much less, give improved results, and it took five years to prove definitely that early planting was not only feasible but reliable and very beneficial. It is emphasised, however, that these results have been obtained for localities with a west-coast climate and that, while some degree of early planting is probably beneficial in most teak planting areas, local experiments must be carried out to determine the earliest safe date in each case, otherwise expensive failure may be experienced. The experiments are now being extended to drier localities.—(*Current Science*, Vol. VIII, No. 1, p. 45, 1939.)

THE FERMENTATION PROCESS IN TEA MANUFACTURE.*

THE fermentation of the tea leaf is a stage in the manufacturing process of tea that has received but little attention in the past. Accordingly a study of the chemical changes taking place in the fermenting leaf has been initiated at the Tocklai Experimental Station, Assam. Although the investigations have not yet been completed it has been possible, from the experimental data already available, to advance a theory for tea fermentation which is in close agreement with the observed facts. This theory and the work which has recently been carried out at the Tocklai Experimental Station are summarised in the following article.

The first stage in the manufacture of tea is the withering process during which the leaf loses water and becomes flaccid. The tea is then rolled, the primary object of which is to rupture the leaf cells and expose the expressed juices to the air. As soon as the leaf tissue is damaged fermentation starts and oxidative changes take place which largely determine the flavour and colour of the infused liquor.

Experimental evidence indicates that tea fermentation is undoubtedly an oxidative process catalysed by enzymes. No polyphenol oxidase can be detected in the tea leaf but peroxidase activity is very marked. Any mechanism for the fermentation process must therefore take account of this quantity of peroxidase and also a reaction involving oxygen uptake as fermenting leaf takes up a considerable amount of oxygen. Moreover tea peroxidase is found to be ineffective in the catalytic oxidation of tea tannin except in the presence of hydrogen peroxide so that any mechanism for the fermentation process must also include a reaction involving the production of hydrogen peroxide.

It is considered that the first stage in tea fermentation is an uptake of oxygen leading to the aerobic oxidation of the ascorbic acid present in the leaf, and the production of hydrogen peroxide. The catalyst involved in the oxidation of ascorbic acid to dehydroascorbic acid is ascorbic acid oxidase. The tea tannin is then oxidized by the hydrogen peroxide, with the catalytic assistance of tea peroxidase, to brown pigments which impart the characteristic colour to a tea infusion. Substances, grouped as non-tans may also undergo oxidation.

$$\text{Ascorbic acid} \xrightarrow{\text{Ascorbic Acid Oxidase}} \text{dehydroascorbic acid} + H_2O_2 \quad (+ O_2)$$

$$H_2O_2 + \text{tea tannin} \xrightarrow{\text{Peroxidase}} \text{tannin o-quinone.}$$

In normally respiring plant tissue the dehydroascorbic acid is again reduced by activated hydrogen (dehydrogenase activity) to ascorbic acid which in its turn reduces the tannin o-quinone back again to tea tannin. A state of equilibrium therefore exists and no permanent changes in the tannins or other catechols take place.

$$\text{Dehydroascorbic acid} \xrightarrow[\text{dehydrogenase activity}]{\text{activated hydrogen}} \text{ascorbic acid.}$$

$$\text{Ascorbic acid} + \text{tannin o-quinone} \rightarrow \text{dehydroascorbic acid} + \text{tea tannin.}$$

When however tea leaf is rolled the equilibrium found in the normally respiring tissue is destroyed. The extensive damage done to the leaf causes a dispersal of reducing substances and co-enzymes responsible for dehydrogenase activity. Consequently there is a considerable reduction in the rate of formation of the activated hydrogen required for the reduction of dehydroascorbic acid to ascorbic acid. This in its turn involves a lower concentration of ascorbic acid and therefore slower reduction of tannin o-quinone to tea tannin. If the tannin o-quinone is not reduced as soon as it is formed it undergoes further irreversible changes into condensation products, a process which will continue until the whole of the tannin has been removed from the system.

It has already been mentioned that substances, grouped as non-tans, may also undergo oxidation during tea fermentation. The production of carbon dioxide in amounts very nearly equivalent to half the total oxygen uptake during fermentation suggests that the non-tans oxidized are carbohydrates, a conclusion which receives additional support from the following experimental observations: During fermentation there is a fall in the reducing sugar content of the leaf, also the decrease in the amount of carbohydrate and the amount of carbon dioxide produced during fermentation are approximately equivalent. There is little doubt that in the oxidative breakdown of the carbohydrate the dehydroascorbic acid present in the system functions as the hydrogen acceptor.

$$\text{Dehydroascorbic acid} \xrightarrow{\text{Zymase}} CO_2 + \text{ascorbic acid.} + \text{glucose}$$

With regard to the rate of oxidation of tea tannin, results show that it is completely independent of the peroxidase content between very wide limits. Generally there is a complete lack of correlation between peroxidase activity and the rate of oxidation of tea tannin in the fermentation process. It is concluded that the amount of peroxidase in the leaf is in excess of requirements and that the controlling factor is the rate of production of hydrogen peroxide. Oxidation of tea tannin cannot proceed at a faster rate than the formation of hydrogen peroxide so that as long as the latter reaction is unaffected wide variations in peroxidase activity are without effect on the rate of oxidation of tea tannin. The hydrogen peroxide necessary for the oxidation of the tea tannin originates in the aerobic oxidation of ascorbic acid, through ascorbic acid oxidase, and it is this reaction that controls the rate of the whole process. This

* By E. A. H. Roberts and (in part) S. N. Sarma. From the Tocklai Experimental Station, Indian Tea Association, Cinnamara, Assam, India.

hypothesis offers a satisfactory explanation of the slower rate of fermentation which Kharikatia leaf undergoes compared with Betjan leaf. Neither the peroxidase nor tannin contents of the two varieties are sufficiently different to account for any variation in the rate of fermentation. It is therefore considered that the Kharikatia leaf is deficient in ascorbic acid oxidase, a conclusion which is supported by a certain, amount of indirect experimental evidence. —(*Biochem. Jr.* Vol. 32, p. 1819, 1938. Ibid. Vol. 33, p. 836, 1939.)

H. F. B.

THE PRESENCE OF LEUCO-ANTHOCYANINS IN CRIOLLO CACAO.*

There is little doubt that the coloured substances present in unfermented cacao beans greatly influence the appearance of the manufactured products and are associated with important differences in flavour. Colours of unfermented cacaos differ very much, ranging from the pure white of the Criollo variety, through the many shades of pink or purple of hybrids, to the deep purple of the Forastero.

It has been definitely established that the colour of the fresh cacao bean, the Criollo variety excluded, is due to anthocyanin pigments. In view of this knowledge it should now be possible to trace this one particular class of pigment substances through the various stages of the fermentation and manufacturing processes and study in greater detail the distribution of colour in various parts of the plants such as the flowers, young leaves and pod tissues.

As a preliminary step in this direction a detailed examination of a Criollo pod has been carried out by Knapp and Hearne, attention being directed to the various tissues of the pod wall itself, in addition to those of the seeds.

For use as a basis of reference in their investigations a solution of cyanidin chloride was first prepared, by the extraction of this pigment from Forastero cacao. The cotyledons of Forastero beans were extracted with cold dilute hydrochloric acid, the mixture filtered and the cyanin chloride of the resulting deep-red solution hydrolysed to cyanidin chloride by increasing the acid concentration and boiling. Finally, by application of a special technique, a pure solution of cyanidin chloride in dilute hydrochloric acid was obtained. The pigment itself was not isolated.

Whereas the solution obtained on extraction of the cotyledons of Forastero cacao with cold dilute hydrochloric acid was deep-red, that obtained from the cotyledons of Criollo cacao, extracted under comparable conditions, was quite colourless. Even after prolonged boiling it developed only a very pale orange colour. When, however, after filtration, the solution was further acidified and boiled, it quickly became brownish-red due to the formation of a number of coloured substances. From this solution a pure solution of a pigment in dilute hydrochloric acid was finally obtained by the same method as that employed for the preparation of the cyanidin chloride solution from Forastero cacao.

Comparison was then made between the colour reactions of this purified solution from Criollo beans and those of the solution of cyanidin chloride prepared from Forastero beans. The reactions were identical in all respects.

A similar agreement in colour reactions was obtained with the purified pigment solutions isolated from other components of the Criollo pod; namely, the seed coatings, the radicle, the placenta and the inner membrane of the pod wall. To obtain the purified pigment solutions from the various components, the same procedure was adopted as in the previous experiments on Criollo and Forastero beans.

From these observations it was concluded that in practically all the parts of the seed and fruit of Criollo cacao there are present certain colourless substances which may be extracted with dilute hydrochloric acid to yield practically colourless solutions. On increasing the acid content, either directly or by prolonged boiling, brownish-red bodies are developed, one of which has been shown to be cyanidin chloride. These facts indicate that Criollo cacao contains a leuco-anthocyanin which, on treatment with strong acid, yields cyanidin chloride. It is suggested that the leuco-anthocyanin is the glycoside of a colourless substance closely related to cyanidin, and that the action of hydrochloric acid on the leuco-anthocyanin is, first to liberate the colourless substance from the carbohydrate residue and then convert it to cyanidin chloride.

This discovery of the presence of leuco-anthocyanins in Criollo cacao may be of use to botanists, especially if the proportionate amounts of leuco-anthocyanin and anthocyanin are related to the extent of inter-breeding of the Criollo and Forastero varieties.

H. F. B.

* By the late A. W. Knapp and J. F. Hearne, extracted from *The Analyst*, Vol. 64, No. 760 p. 475, 1939.

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REVIEWS.

SEED AND POTTING COMPOSTS, WITH SPECIAL REFERENCE TO SOIL STERILIZATION.

By W. J. C. Lawrence and J. Newell. *George Allen and Unwin Ltd.*, London, 1939. Price 3*s*. 6*d*.

This little book will be found worth many times its modest cost to gardeners whose work includes the management of glass.

The fact that the authors are the Curator and Assistant Curator of the John Innes Horticultural Institution is itself a recommendation, since the plant breeding and experimental work in genetics for which that Institution is famous depend ultimately for their success on a very high standard of gardening. In some experimental work, as Sir Daniel Hall has pointed out in his foreword, the results will be valueless unless every healthy seed produces its plant, and this requirement leaves no room for bad technique.

The book had its origin in an attack of wilt on primulas in the Merton houses, and the unsatisfactory results of soil sterilization adopted in an effort to control it. The initial problem led on to nothing less than a thorough investigation of the principles and practice of composting for pot plants. The outcome was the standardisation of two composts, one for seeds and one for potting, which are claimed to be suitable for almost all kinds of plants, and the claim is convincingly supported by photographs.

Whilst the importance of a good greenhouse technique may seem small in tropical horticulture by contrast with English conditions, it is by no means negligible, and it will grow as the standard of gardening rises. Already a certain amount of glass—for the control of water-supply and light rather than temperature—is found indispensable to many plant breeding programmes, and there is room for a great extension of its use both in ornamental and in vegetable gardens. Present methods of preparing potting soils are, in the reviewer's experience, far from satisfactory, and the little volume under notice provides stimulating suggestions for their improvement.

Put very briefly, the keys to success are shown to be selection of materials that can be standardised, sterilization of the loam ingredient before mixing, and judicious additions of inorganic manures. The authors' formulae may or may not be directly applicable in the tropics. The answer to that question depends largely on the possibility of obtaining at a reasonable cost the peat which is an essential ingredient of "John Innes" composts. But of the applicability of the principles they have laid down there can be no doubt, and anyone interested in growing better pot plants will be well advised to read what Messrs. Lawrence and Newell have written.

E. E. C.

AGRICULTURE IN THE TWENTIETH CENTURY.

An unusual but extremely useful book, *Agriculture in the Twentieth Century*, Oxford Clarendon Press, 1939, 440 pp. Price 15*s*., has been published under the able editorship of Sir Daniel Hall, one of the chief organisers of agricultural research in Great Britain. Sir Daniel has marshalled fifteen experts on agriculture to write each an essay on his own particular subject. The essays cover all the important aspects of British Agriculture to-day: the present state of technical knowledge of the chief branches of the industry; business aspects of agriculture; agriculture and nutrition; and, what is particularly desirable to-day, various aspects of the involved partnership of agriculture and government, both national and local. Among the distinguished list of contributors are: A. W. Ashby, Sir J. B. Orr, C. S. Orwin, Sir E. J. Russel and J. A. Venn.

Each of the essays is entirely separate, but, in spite of this and the wide range of subjects discussed, a remarkable consistency of treatment is to be observed throughout the book. Each subject is treated in simple language describing concisely steps which have led to the position to-day. Detailed technical discussions have been excluded throughout, but the book presents a large body of technical information in a very palatable form.

This book will undoubtedly be of great value to students, specialists and farmers. It is to be hoped also that some, if not many, copies may reach the hands of townspeople to whom it is thoroughly recommended. No one having read the book can fail to realise that agriculture in Britain is faced with general and technical problems of great complexity, and, more particularly, that some of the most able men in the country are applying themselves very successfully to the solution of these problems for the good of farmer and townsman alike.

A. L. J.

* * *

THE GENETICS OF COTTON.

By Sydney Cross Harland. London. *Jonathan Cape*. 10*s*. 6*d*.

The usefulness of this publication to the elect band of cotton breeders scarcely needs comment. There is no man better qualified to write on the genetics of cotton than Dr. Harland, and by combining a review of the literature with his own work and opinions he has produced a handy work of reference, which is sure to be frequently consulted by specialists.

But it would be a pity if the volume were overlooked by botanists not working on cotton, for it contains much of interest to a far wider circle, and particularly to all who are interested in plant relationships. Many genera that contain crop-plants are very difficult to the systematist,

and *Gossypium* is an outstanding example of the manner in which genetics, cytology and plant breeding are now contributing to a new taxonomy. A welcome simplification and rationalisation of this assemblage of plants during recent years is largely due to the author and his colleagues and though the process is not yet complete it provides an interesting demonstration of procedure for workers in other groups.

A chapter on the comparative genetics of the genus *Gossypium* is necessarily a very brief outline of views which Harland has developed more fully elsewhere, and scarcely does justice to his achievements in the elucidation of the highly complex inheritance observed in cottons. Brevity is indeed a notable feature of the book, and in the main commendable, but in this and some other places tantalising.

Search for faults in detail reveals a number of misprints and some unorthodox citations like *G. aridum* Skovsted (nov. comb.) for *G. aridum* (Rose and Standley) Skovsted, but the general layout is pleasing and the tabular arrangement of data greatly facilitates the reader.

E. E. C.

* * *

RECENT ADVANCES IN GENETICS.

By F. W. Sansome and J. Philp, *J. and A. Churchill Ltd.*, London, 2nd Edition, 1939, pp. vi + 412, figs. 55. Price 18*s*.

Keeping up to date with the results of the latest researches is a difficult problem, even in so specialised a subject as genetics. In the most extensive reading it is easy to overlook an important paper, and regular reading of scientific journals is apt to result in a very disjointed picture of the subject as a whole. Such a book as the one under review has the great merit of co-ordinating recent literature so that papers advancing one particular branch of the subject are considered in their relation to each other. This is particularly important where our understanding of a problem is being advanced by investigations in widely different organisms, as for example *Drosophila* and maize.

It would not be reasonable to expect such a book to be easy reading, and it deals with material too recent for the full effect on genetic theory to be clear. There are chapters dealing with the main sections of genetic theory, and in them the most recent facts are well presented. As might be expected, discussions and conclusions occupy a comparatively small part of the book, but they are valuable, and, allowing for the fact that the work discussed is very recent, adequate.

The reviewer would have liked to see a chapter devoted to quantitative inheritance and the application of genetics to plant breeding. Perhaps when another edition is required, the advances in applied genetics will be sufficient to justify the devotion of a chapter to them.

J. B. H.

A HISTORY OF TROPICAL MEDICINE.

By H. Harold Scott in two volumes. *Edward Arnold & Co.*, London, 1939, Vol. I, pp. 648, Vol. II, pp. 649-115. Price £2 10*s*. 0*d*.

In the preface to *A History of Tropical Medicine* Dr. Scott states that there was no difficulty with regard to the choice of a subject, but that the difficulty lay in the fulfilment of his task. There can be no doubt that despite the difficulty the task has been fulfilled in a delightful manner. The subject is one which must interest not only the medical profession and the historians, but also all those concerned with the tropics. It is indeed fascinating to study the problems which presented themselves to the pioneers and to trace their development towards solution through hardships and doubt.

The history of tropical medicine is complex and Dr. Scott truly describes it as " a tree whose roots lie deep in the dark, but whose branches are extensive, fruitful and evergrowing, whose nurture is beyond the capacity of one man alone to maintain". A full and comprehensive account of the long struggle against tropical disease is given, which impresses us with the fact that the struggle is still going on although the work to-day is lightened by the discoveries of our predecessors. To-day we have reaped the great benefits bestowed upon us to such an extent that the tropics are now no longer designated as impossible to live in because of pestilence or plague.

The plan followed in this book emphasises for the reader the problems that arose, and the difficulties encountered in their solution. The historical review commences with chapters on the Navy and Army, both of which played a big part in the history of tropical medicine. The author then deals with the Colonies, and enables the reader to visualize the conditions under which the problems had to be solved. There follow chapters on the diseases, dealt with in detail. There are two chapters on great engineering enterprises—the Suez and Panama Canals—in the building of which medical men played such an important part. The Slave Trade is also rightly accorded a chapter, as it was conducive to the spread of disease amongst the captives and to those engaged in the trade.

The chapter on tropical diseases connected with food is of especial interest in view of present day interest in nutrition. Bibliographies of some of the outstanding personalties in the sphere of tropical medicine conclude this enterprising and absorbing book.

Throughout its pages many references to the West Indies are to be found, especially in the chapters on the Navy and Army, the Slave Trade and diseases prevalent in these islands.

This history is an impressive account of the advances which have been made in tropical medicine. Considerable stress is laid, however, on the fact that each disease still has its own unsolved problems, and that tropical research must go on and that the fight against disease may not be relinquished for a moment.

M. G.

EFFECTIVE PHOSPHATES IN CANE JUICES.*

ALTHOUGH the importance of the phosphate content of juices in determining their behaviour towards clarification is generally recognised, the exact phosphate requirements reported by different authors vary within wide limits [Walker (1), McAllep and Bomanti (2).] Some have concluded [Lanier (3)] that the initial-colloid content is more responsible for the efficiency of clarification than the phosphate content itself.

In Natal, where the juice colloids are high and the soil deficient in phosphates, the P_2O_5 content of juices is raised to 0.05 – 0.06 per cent. (4) to secure good clarification. The work of Keane and Hill (5) on the filtrability of raw cane sugars, of Carrero (6) on P_2O_5 contents P.O.J. 2878 juices, of Beater (7) on South African juices and of McRae (8) on the nature of the phosphates present, shows that the entire phosphorus in the juices is not available for clarification. The authors believe that it is only the phosphate which is in true solution or which gets into solution on heating which reacts with the added lime to form the calcium phosphate precipitate; this portion of the phosphate is known as the *effective phosphate.*

The Separation of 'effective' and 'non-effective' Phosphates.—The 'effective' phosphate was dialysed out through a cellophane membrane, at 80°C., against distilled water, employing a muslin-filtered sample of juice (50 c.c.) obtained by crushing in a three roller vertical mill, under moderately heavy pressure. 50 c.c. of the juice is then separately analysed for total phosphates.

The dialysate in the beaker is collected and replaced by fresh distilled water daily in the initial stages and later on, on alternative days. The dialysis was continued for 7 days, with daily changes of water; all the dialysate was collected, concentrated, evaporated to dryness with a few drops of calcium acetate, ashed and the P_2O_5 estimated gravimetrically by precipitation as ammonium phosphomolybdate. The results obtained with two varieties, on different dates, on the whole juice and juices from top and bottom portions are given in the table.

Table I.

Variety.	Total P_2O_5 gm./litre juice.	Dialysable P_2O_5 (Effective P_2O_5).	
		P_2O_5 gm./litre.	Per cent. Total P_2O_5.
I—(*a*) Co. 312 ...	0.5850	0.5446	93.09
(*b*) Co. 331 ...	0.4284	0.4149	96.85
II—(*a*) Co. 312 ...	0.5874	0.5754	97.96
(*b*) Co. 331 ...	0.4751	0.4648	97.83
III—(*a*) Co.312			
Top ...	0.6076	0.5861	96.46
Bottom ...	0.8150	0.7875	96.63
Whole ...	0.6942	0.6761	97.36
Co. 331			
Top ...	0.5116	0.4984	97.42
Bottom ...	0.7505	0.7370	98.20
Whole ...	0.6130	0.5998	97.85

Table I reveals that in the varieties examined the effective phosphate is more than 95 per cent. of the total phosphate. This is in disagreement with the results of most of the earlier workers, who obtained by their methods 50-70 per cent. of the total phosphates as possibly being available for defecation. It will also be noticed that the effective phosphate is more in the bottom juice than in the top juice. Whether these differences are common to all the Indian varieties and at different periods of growth or due to milling conditions or to defects in the methods of determination—these are factors now under investigation.

References.

(1) Walker, H., *Ind. Eng. Chem.*, 1923, XV, 164.
(2) McAllep and Bomanti, *Hawaiian Planters' Record*, XXVI, 122.
(3) Lanier, "Process", *4th Annual Conf. of Association Sugar Tech.*, Cuba, p. 93.
(4) Farnell, *Int. Sugar. Jour.*, 1929, p. 149.
(5) Keane and Hill, *Ind. Eng. Chem.*, 1931, XXIII, 421.
(6) Carrero, *Rept. Agric. Expt. Station*, Puerto Rico, Mayaguez, 1931, p. 11.
(7) Beater, *Proc. South African S. Tech. Association*, 1937, p. 82.
(8) McRae, Ibid., 1929, p. 54.

* By S. N. Gundu Rao and Kripa Shankar, Imperial Institute of Sugar Technology, Cawnpore. *See Current Science*, Vol. VIII, No. 5, 1939.

OBITUARY.

MR. B. C. G. CHARLES.

IT is with deep regret that we have to record the death in England, as a result of a motor accident, of Mr. Bryan Cecil Gwyther Charles who joined the Imperial College of Tropical Agriculture as a Colonial Agricultural Scholar in 1931. Mr. Charles was a nephew of Mr. R. Cecil Wood, formerly Professor of Agriculture at this College. He was educated at the South Eastern Agricultural College, Wye, where he obtained the Diploma in Agriculture. In 1932 he qualified for the Associateship and was appointed Agricultural Officer to the Nyasaland Department of Agriculture of which he was still a member at the time of his untimely death. Mr. Charles was a popular student and made many friends during his stay in Trinidad. We extend our deepest sympathies to his widow and to his relations in their very sad loss.

CHEMICAL NOTES.

(Compiled by the College Department of Chemistry and Soil Science.)

The Chemistry of Natural Rubber.

A separation of the purely organic non-hydrocarbon constituents of rubber from the hydrocarbon and mineral-containing constituents has recently been achieved by K. C. Roberts (*J. C. S.*, 1938, p. 215). From the non-hydrocarbon fraction, four constituents were isolated including a newly discovered constituent termed caoutchol, a tough non-tacky and highly elastic substance comprising 2-5 per cent. of the solid matter of raw rubber. From "precipitated rubber" (the fraction which includes the hydrocarbon and mineral-containing constituents), three substances were isolated, including a polyterpene hydrocarbon called caoutchene. Caoutchene, which comprises 89 per cent. of the solid matter of raw rubber, was found to be of a tacky nature and lacking in toughness and elasticity. In the crude state it is associated with nitrogenous matter of an obscure nature.

With regard to the chemical relationship between caoutchol and caoutchene it is considered that the former is caoutchene dihydrate $C_{80}H_{130}(OH)_2$.

On the basis of the feeble elasticity of caoutchene —the major constituent of rubber—and the remarkable degree of elasticity displayed by caoutchol Roberts suggested that the elasticity of raw rubber is essentially that of the minor constituent caoutchol. This substance by virtue of its own state of association and of its power of forming further associated links between its hydroxyl groups and the residual affinity of the caoutchene molecules, acts as a binding material which imparts its own elasticity to the entire mass. Further evidence is also adduced in favour of this two-phase inter-molecular theory.

It is stated that no oxidative or other changes take place in the constituents during their isolation. Taking into consideration the process employed for the separation of the constituents it is however considered by J. W. Haefele and E. M. McColm (*J. C. S.* 1939, p. 676) that oxidative changes are almost certain to occur and that the caoutchene isolated by this process may differ appreciably from that present in the raw rubber. It is possible therefore that the tacky, non-elastic nature of the separated caoutchene is due to these oxidative changes and not, as Roberts suggested, to the removal of caoutchol. In the parent material, caoutchene—like caoutchol—may be tough and elastic. If this is the case then the two-phase intermolecular theory can no longer be considered tenable.

With these considerations in view, Haefele and McColm carried out the separation of caoutchene by a similar method to that employed by Roberts, but in the presence of oxygen-free nitrogen. Isolated under these conditions, caoutchene was found to be non-tacky and quite elastic. It began to show tackiness after 24 hours exposure to air.

On this evidence therefore the removal of caoutchol from rubber does not cause tackiness and loss of elasticity. These properties appear when "caoutchol-free" rubber suffers oxidation, but do not appear if oxygen is excluded from the rubber during or after its preparation.

* * *

Carotene in Oranges. A. L. Taylor and P. J. Witte.

Estimations of carotene in the juice from various types of American oranges were made, each sample being obtained from 24 oranges. Fifty cc. of the strained juice were placed in a flask through which a gentle current of air circulated, concentrated to a syrup on the water-bath, and analysed by Guilbert's method (*Ind. Eng. Chem., Anal. Ed.*, 1934, 6, 452) 100 cc. of alcoholic potassium hydroxide solution being used for the saponification. The final solutions in petroleum spirit were immediately compared with a dye standard in a colorimeter. Instead of the dye solution prepared by Guilbert (*loc. cit.*), a 0.036 per cent. solution of potassium dichromate was used for the comparison. This was colorimetrically equivalent to 2.66 mg. of carotene per litre. The average carotenoid pigment was much higher in the Californian than in the Florida varieties of oranges. The following results were obtained:—

Variety.	No. of Samples.	Carotene mg. per litre.	
		Average	Range.
California Valencias ...	14	1.65	0.65-2.74
California-Washington navels ...	68	1.07	0.24-2.97
Florida Valencias ...	34	0.57	0.18-1.05
Florida pineapple oranges ...	32	0.34	0.05-0.83
Florida assorted ...	16	0.32	0.15-0.70

Some of the varieties showed a possible seasonal trend in carotene value, but the variation between samples was too great to enable a decisive conclusion to be drawn. The results for the juice did not appear to depend on the colour of the skins.—(*Analyst*, Vol. 63, No. 745, p. 282.)

The second edition of R. C. Wood's "Note Book of Tropical Agriculture" contains information on weights and measures, mensuration and surveying, buildings and roads, machinery, labour, soils, manures, crops, foods and feeding, livestock, dairying, recipes, statistics, current prices and Imperial Agricultural Institutes and Bureaux. Copies (price five shillings, post free) may be obtained on application to the Editor, *Tropical Agriculture*, Imperial College of Tropical Agriculture, Trinidad, B.W.I.

SUGAR NOTES.

(Compiled by the College Department of Sugar Technology.)

A New Plastic Compound from Sugar-cane Bagasse.

A plastic compound made from the lignin and cellulose of sugar-cane bagasse, has been manufactured by chemists of the United States Department of Agriculture at the Agricultural By-products Laboratory, Ames, Iowa. It is estimated that this new compound can be manufactured for less than half the cost of the cheapest synthetic plastic compound now on the market.

In recent years, it is pointed out, production of synthetic plastic compounds has expanded rapidly. But the comparatively high cost of moulding powders, mostly alkyd and phenolformaldehyde resins, confines plastic manufacture largely to small articles. It seems unlikely that the price of these raw materials can be reduced materially. With a low-cost moulding compound made with only a small amount of expensive chemicals, the plastics industry could branch out into broader fields, such as the manufacture of furniture, building materials, and motor car parts. Also, where certain qualities of the costlier phenolformaldehyde resins are not required, the cheaper product could be substituted.

Moulding compounds may be made from the bagasse by three methods. The first, and cheapest, is hydrolysis with acid. Counting the cost of bagasse at $8 a ton, baled and delivered at the factory, it is estimated that a plastic compound can be made by this method, in which the cost of material will be slightly more than two cents a pound. Plastics made from the compound, while not so strong as some synthetic products now in use, are quite moisture resistant and would be suitable for moulding bathroom tile for both floors and walls. They apparently have the wearing ability of wood and may be sanded and repolished through the entire body.

The second method is hydrolysis in the presence of aniline, a coal tar derivative. The material cost of plastics from this process will be more—about 4½ cents a pound—but they are as strong as plastics now in use. In tests it has resisted bending pressures up to 9,000 pounds per square inch. They are slightly less water-resistant than plastics made by the first method, but do not warp and may be sawed, drilled and, with care, nailed. These properties suggest uses as card table tops, desk tops, and building panels.

Treating the bagasse with sodium hydroxide and furfural is the third process. In quality plastics from this method are about midway between the other two. They flow better and mould at 2,500 pounds per square inch compared with 3,500 for the second treatment. They may be put to the same uses as the plastic from the second treatment.

Either of the plastics made from the last two processes do not shatter easily. In fact, neither breaks when struck hard enough with a hammer to cause a dent.

It is possible that other farm waste materials, such as cornstalks and straw from small grains, may be used in making plastics by the same processes. All have in common a composition of lignin and cellulose, basis.—(*Sugar News*, Vol. XX, No. 7, 1939, pp. 291-292.)

* * *

The F. L. and D. H. Process of Clarification as applied at Guanica Central, Puerto Rico.

With the increased planting of POJ cane varieties in Puerto Rico, and especially of 2878, which does very well in that country, Guanica was faced with a serious clarification problem. It was found that the Oliver filters returned a good deal of juice to the clarifiers which were already over-loaded, causing them to give a thin mud ; this in turn threw more work on the filters, thus setting up a vicious circle.

Seeing an article in the *I.S.J.* on the F.L. and D.H. process of clarification* the fabrication staff communicated with its author, Mr. J. G. Davies, as the result of which the process was installed at Guanica in 1936. It was found that the tests on the factory scale were successful as long as the pH control was exact, and the temperature of the first limed juice was not allowed to drop below 195°F. Below this temperature the final liming did not produce a rapid clarification. However, the results of the 1936-37 crop were sufficiently good to warrant installing a greater heating capacity on the first heating for the following crop.

With this new heater, three 20 ft. 5-compartment Dorrs in conjunction with four 12 by 8 Olivers were sufficient to handle juices from 7,000 tons of cane. It is now believed that Guanica's gallonage of clarifiers per ton of cane is as low as the average of other factories in Puerto Rico also handling large amounts of POJ canes.

Procedure.

" We first add lime of 10° Bé. to give 6.2 to 6.4 pH in the juice scales, where the juice mixes thoroughly with the lime. This juice then goes to mixing tanks, and is pumped to first heaters, heated to 200°F., and returned through a turbulent tank where lime is manually added as 10°Bé. cream continuously to a pH of 8.0 to 8.4 (as determined on a spot plate). Juice falls into the pump tank and passes through final heaters to Dorr clarifiers at 216 to 218°F. Juices are clear and bright and mud reasonably thick. The above procedure produces a defecated juice with 7.2 to 7.4 pH. Syrup purity for 1938 was 1.48 over the mixed juice purity against 1.26 average rise for five previous years ".—(*Inter. Sugar Journal*, Vol. XLI, No. 488, 1939, pp. 320-321.)

* *I.S.J.* 1938, pp. 298-300